



Original communication

Orbital aperture morphometry in Brazilian population by postero-anterior Caldwell radiographs

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ARTICLE INFO

Article history:

Received 9 August 2011

Received in revised form

28 February 2012

Accepted 21 April 2012

Available online 25 May 2012

Keywords:

Sex determination

Orbital aperture

Morphometry

Caldwell radiograph

ABSTRACT

Morphological variations of the orbital aperture measurements act as parameter for sexual and ethnic determination. The aim of this study evaluated the dimensions of the orbital aperture in Brazilian subjects to verify its relationship to gender. The orbital apertures of 97 individuals were examined through Caldwell radiographic technique. The maximum width and height of the orbits were measured. The inter-orbital distance, which is the minimum distance between the medial walls of the orbits, was also measured. Statistical analysis was performed through the Pearson test for correlation between measurements and Student *t* test with 5% significance level to verify the relation between the gender. Determination of significance attributed to non-parametric Kruskal–Wallis and Mann–Whitney tests ($p < 0.05$). The test of intra-class correlation (ICC) showed satisfactory repeatability (ICC = 0.9932, $p < 0.0001$) between measurements performed, taken at different time periods. The ICC showed satisfactory repeatability (ICC = 0.9932, $p < 0.0001$) between measurements performed at different periods. In the *t* test, significant differences between the genders, the width, and area of the orbital aperture were obtained. In conclusion, if the area of orbital aperture is $< 8.5 \text{ cm}^2$, the skull is likely to be a female; if it is $> 9.0 \text{ cm}^2$, it is likely to be a male. If the width of orbital aperture is $< 3.5 \text{ cm}$ the skull is likely to be a female; if it is $> 3.5 \text{ cm}$, it is likely to be a male. If the inter-orbital distance is $< 2.4 \text{ cm}$ the skull is likely to be a female; if it is $> 2.5 \text{ cm}$, it is likely to be a male.

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1. Introduction

Several parameters can be applied in facial reconstruction from the skull of an unknown individual.¹ Width and position of the mouth and the projection of the eyeball² are used to determine the facial features.³ This morphological variability is necessary to understand the ethnic differences and may be used and analysed by radiography in the forensic context.^{4,5}

Human identification based on morphological variations of isolated bones or complete skeleton is a complex process.⁶ These variations of orbital aperture and orbital bone may be used in forensic medicine as a parameter for sexual and ethnic determination.⁷

Dentomaxillofacial radiology is a useful tool in dentistry to reveal characteristics of craniofacial structures.⁸ Several radiographic techniques are used to determine the dimensions of these structures. The postero-anterior Caldwell technique was used in the dentistry area and was effective to gender identification of Brazilian subjects.⁹

Thus, the aim of this study was to evaluate the orbital aperture dimensions in Brazilian subjects and verify its relationship to gender.

2. Material and methods

We evaluated radiographs of 97 Caucasian individuals, taken by the Caldwell radiographic technique with front-nasal support (Fig. 1). The sample was composed of 50 females and 47 males, between 18 and 36 years old, who were previously examined and

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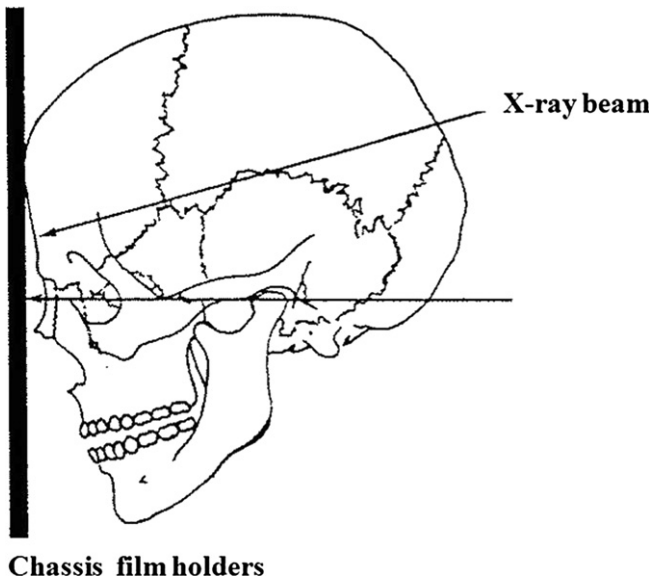


Fig. 1. Diagram of Caldwell radiographic technique with front-nasal support.

evaluated in respect to the anatomic integrity of the orbits. This study was approved by local Committee of Ethics in Research.

Radiographs were taken by the same radiologist, using Kodak radiographic film, size 18×24 cm. Postero-anterior teleradiograph was performed with an X-Ray Telefunken X-15 apparatus with a distance of 1.52 m from the source to film, using 80 Kvp exposure and time of 1.2 s at 20 mA. These radiographs were taken using a roentgenographic cephalometric apparatus.

The Caldwell technique with front-nasal support was selected to obtain the proximity of the orbits to the film, resulting in less magnification and distortion.⁹ The diagram of Caldwell technique for examination of the orbital aperture is shown in Fig. 1. The contour of the orbital aperture was performed three times for each radiography under the light box using tracing paper and mechanical pencil of 0.5 mm thickness by the same examiner. The measurements were performed at different periods to conduct an intra-observer calculation based on intra-class correlation (ICC).

The bordering points of the orbital aperture on radiographic images were obtained with a transparency plate for HP® Scanner

connected to an INTEL® PENTIUM II computer. The linear measurements and the areas of orbital aperture were obtained using the program SIARCS 3.0 for Windows, developed by EMBRAPA – São Carlos – São Paulo – Brazil.

We measured the major width (left and right) and maximum height (left and right) of the orbits, and the inter-orbital distance, which is the minimum distance between the medial walls of the orbits (Fig. 2). The linear measurements, obtained from each radiograph, were expressed in cm and the areas in square (cm^2).

Statistical analysis was performed through Pearson test for correlation between measurements and Student *t* test with 5% of significance level to verify the relation between the genders. Determination of significance was attributed to non-parametric Kruskal–Wallis and Mann–Whitney tests ($p < 0.05$).

3. Results

The ICC showed satisfactory repeatability ($\text{ICC} = 0.9932$, $p < 0.0001$) between measurements performed at different periods.

Figs. 3–5 show, respectively, the ratio of the area, width and height of the orbital aperture according to gender and side.

The area of the orbital aperture of the male gender was significantly (Kruskal–Wallis, $p < 0.05$) larger than the female gender, and the left orbital aperture did not differ from the right, considering each gender separately.

The width of orbital aperture showed a similar pattern, although the right orbital aperture of the female gender did not show statistically significant differences related to the left male orbital aperture. The maximum height of the orbital aperture showed no statistically significant differences (Kruskal–Wallis, $p > 0.05$) between genders or between the sides.

The inter-orbital distance showed significant differences (Mann–Whitney test, $p < 0.05$) between genders (Fig. 6).

Table 1 shows the correlation (Pearson test, r_P) between the measurements. r_P values higher than 0.8 show a high correlation between the measures.

4. Discussion

Gender determination based on skeletal characteristics has a crucial role in legal medicine and forensic anthropology. Researchers have proposed two approaches, morphological (non-

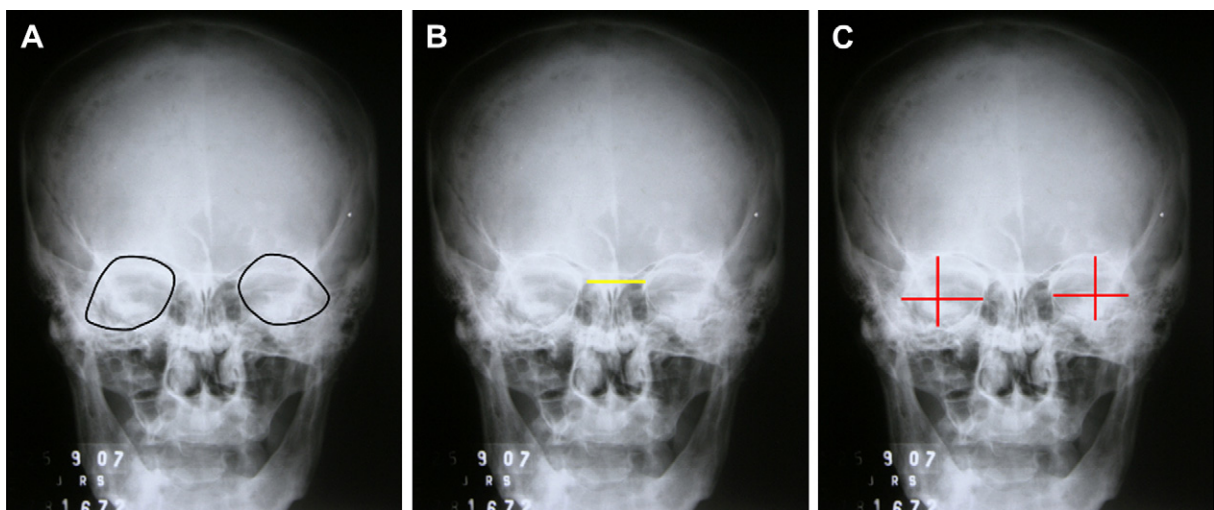


Fig. 2. Measures of orbital aperture: A- represents the orbital aperture area; B- horizontal line represents the inter-orbital distance; C- horizontal line represents the width and vertical line represents the height of the orbital aperture.

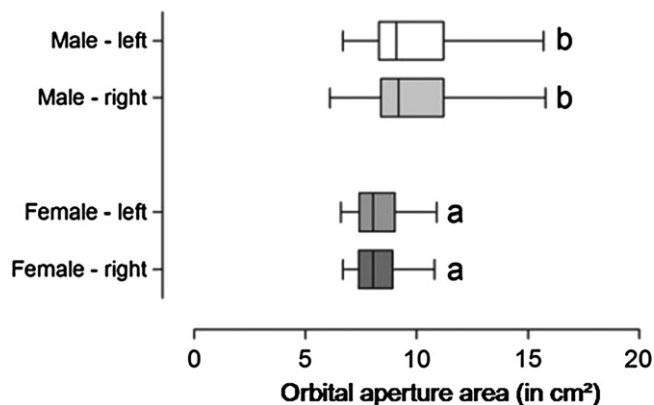


Fig. 3. The ratio of area of the orbital aperture according to gender and side.

metrical) and metrical, for the determination of sexual characteristics from bones.¹⁰ Anthropometry is used to obtain measurements of anatomical structures to assist in identifying the age, stature, gender and several aspects related to individual or ethnic group.¹¹ It is well known that the skull provides elements for gender identification.¹²

Orbit is an important anatomical landmark that comprises the crossroads of the central nervous system, connections with the nose, paranasal sinuses and the structures related to the eyeball function.¹²

The postero-anterior projection described by Caldwell is designed to provide a clear view of the cavities of the face as the orbits, the frontal and maxillary sinuses and piriform aperture without loss of definition by superimposition of portions of the sphenoid bone. The central X-ray is aligned to exit between the orbits at the base of the nose, eliminating the superposition with the petrous ridge of temporal bone.¹³

The present study demonstrated by Caldwell radiographic technique, that the gender difference was highly significant and that orbital aperture width and area were larger in males than in females in Brazilian individuals. However, the maximum height of the orbital aperture showed no statistically significant differences between genders. Nitek et al.¹² evaluated the orbital aperture width and height in 100 Polish dry human skulls and concluded that these dimensions were larger in male than in female. The authors presented a mean height of 3.36 mm and 4.26 mm on the right side, and on the left side a height 3.36 mm and width of 4.24 mm in the orbital aperture of male skulls; while the mean height of 3.36 mm and 4.03 mm on the right side, and 3.46 mm on the left side and

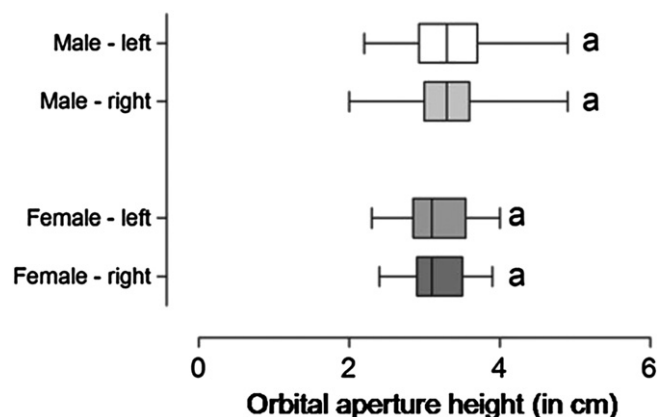


Fig. 5. The ratio of maximum height of the orbital aperture according to gender and side.

width of 4.16 mm in the orbital aperture in female skulls. The results of these authors and our work suggest that using different methods, the Polish and Brazilian male individuals have the dimensions of the orbital aperture larger than the female. These results demonstrate that specific values of bony anatomical structures of different populations are very important for gender determination in cases of partial or complete skeleton.^{12,14,15}

The orbital aperture area according to the study of Kadanoff and Jordanow¹⁶ ranged between 108.1 and 131.0 mm² in German skulls, showing similar results to our work (mean of 100 mm²). Bakholidina¹⁷ measured the distance from nasion point to the line between supraorbital points and found it was equal to 10.0 and 8.0 mm in Mongoloids and Caucasoids, respectively. This author reported that the inter-orbital distance, as performed in the present study, also contributes to identify Mongoloid and Caucasoid individuals.

Cheng et al.¹⁸ performed several measurements in orbits of Chinese skulls and concluded that males had significantly longer distances than females and suggested that this may be related to the larger size of the male compared with the female skulls in the Chinese population. In this study, only the maximum height of the orbital aperture showed no statistically significant differences between genders.

Pommier et al.¹⁹ evaluates a new method for foetal age estimation based on orbital measurement including the potential chromosome trisomy 21 of the foetus. Six orbital and one facial computed tomography (CT)-scan measurements were taken on 71 fetuses ranging from 14 to 41 weeks of gestational age. Forty-eight fetuses were healthy and 23 fetuses presented the Down

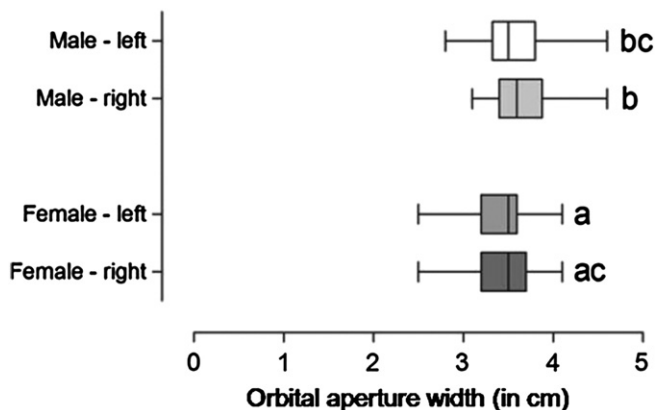


Fig. 4. The ratio of the largest width of the orbital aperture according to gender and side.

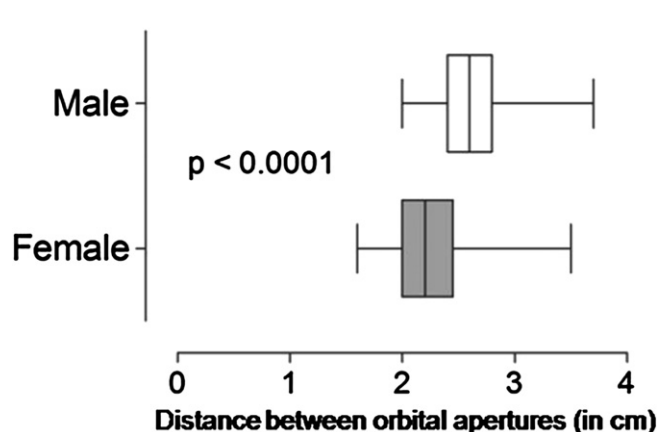


Fig. 6. The inter-orbital distance according to gender.

Table 1

The correlation (Pearson test, rP) between the measurements. rP values higher than 0.8 show a high correlation between the measures.

	Right width	Left width	Right area	Left area	Right height	Left height
Female						
Left width	0.8888					
Right area	0.6051	0.5569				
Left area	0.6002	0.5731	0.8737			
Right height	0.6257	0.6387	0.5932	0.7056		
Left height	0.5627	0.5414	0.5137	0.6813	0.7633	
The inter-orbital distance between the orbital apertures	0.1191	0.1226	−0.1825	−0.1664	0.1953	0.2341
Male						
Left width	0.7961					
Right area	0.637	0.5416				
Left area	0.6294	0.5506	0.9654			
Right height	0.5169	0.551	0.7535	0.7477		
Left height	0.4868	0.5515	0.7622	0.7631	0.8869	
The inter-orbital distance between the orbital apertures	0.2137	0.1001	0.043	0.0445	0.2311	0.0777

syndrome (trisomy 21). These authors affirmed that the measurements of orbital aperture were useful to identify the pathology when compared with measurements of healthy fetuses, and demonstrated that the orbital aperture of these fetuses may contribute to the field of forensic sciences, where age determination is needed, but, where the pathologic condition of the foetal remains is not always known. Thus, Pommier et al.¹⁹ affirmed that the dimensions of orbit may contribute in clinical, forensic, archaeological contexts and clinical diagnosis and treatments.

Thus, this study concluded that:

- (i) If the area of orbital aperture is $<8.5 \text{ cm}^2$, the skull is likely to be a female; if it is $>9.0 \text{ cm}^2$, it is likely to be a male.
- (ii) If the width of orbital aperture is $<3.5 \text{ cm}$ the skull is likely to be a female; if it is $>3.5 \text{ cm}$, it is likely to be a male.
- (iii) If the inter-orbital distance is $<2.4 \text{ cm}$ the skull is likely to be a female; if it is $>2.5 \text{ cm}$, it is likely to be a male.

Conflict of interest

None declared.

Funding

None declared.

Ethical approval

None declared.

Acknowledgements

The authors are thankful for the financial support granted by Coordination for the Improvement of Higher Level or Education Personnel (Capes) and National Council for Scientific and Technological Development (CNPq).

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